Organic Weed Management using Propelled Abrasive Grit Management

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Introduction

- Weed control and crop fertility are sited as the most challenging aspects of organic system management.
- The use of air-propelled abrasive grits provides control of weeds in crop rows as seen in Figure 1 (Forcella et. al., 2010; Erazo-Barradas, 2016).
- Selecting specific grits may provide nitrogen to the crop and control weeds simultaneously.

Figure 1. A: PAGMan spraying Sustane 8-2-4 on corn in Morris, MN 2015. **B:** Season-long weedy check in soybeans in Morris, MN 2016. **C:** Sustane 4-6-4 applied 2 times in-rows with between rows flamed at V5 in Morris, MN 2016.

Objective

- Quantify nitrogen release from 5 different grits at two application rates and three timings in a laboratory incubation.

Materials and Methods

Laboratory Incubation [modified from Sistani, K. et al. (2008)]
- Completely randomized design with four replications
- Grits were applied at two rates, 0.3 g or 0.9 g grit/250 g of silty clay loam soil with 0.9 g grit applied at each of the application timings:
  - 0 d after initiation only, 0 and 10 d after initiation, or 0, 10 and 20 d after initiation to simulate different timings of in-field grit applications.
- Grits used:
  - Sustane 8-2-4 (Turkey Litter)
  - Sustane 4-2-2 (Turkey Litter)
  - Phytaboost Plant Food 7-1-2 (Soybean Meal)
- The soil was maintained at 30% moisture under laboratory conditions at about 25 ºC.
- Nitrate (NO_3^-) and Ammonia (NH_4^+) concentrations were quantified at time 0, 7, 14, 28 and 56 d after initiation by removing a 16 g soil sample and extracting with $1M$ KCl.
- Extract was analyzed for NO_3^- and NH4+ through a cadmium reduction method using an ASTORIA-PACIFIC micro-segmented flow analyze.

Statistical Method:
- Nitrate (NO_3^-) and Ammonia (NH_4^+) were combined to determine the release from grits by using a first-order rate equation (modified from Wang et al., 2011).
- The total nitrogen released analysis of variance performed using R function aov.
- Least Significant Difference of total nitrogen released determined using R, agricolae, LSD.test.
- Slopes of nitrogen release curves were determined using Data Solver on Microsoft Excel.

Results

Table 1. Analysis of variance table for percent nitrogen released 56 d after initiation

	Df	Sums of Squares	Mean Sums of Squares	F Value	Pr(>F)
Treatment	11	5028	457.1	17.62	1.47E-09
Residuals	27	700	25.9		
				R-square: 0.89	

Table 2. Percent of nitrogen released 56 d after initiation.

Grit	Amount (g/250 g soil)	% Nitrogen Released	µg Nitrogen Added
Sustane 4-2-2	0.3	82 a	45 d
Phytaboost	1.8	81 a	520 b
Sustane 8-2-4	0.3	76 ab	73 f
Phytaboost	0.9	72 b	230 de
Phytaboost	2.7	71 b	690 a
Phytaboost	0.3	68 bc	73 f
Sustane 8-2-4	0.9	67 bcd	190 e
Sustane 4-2-2	1.8	60 cd	200 e
Sustane 4-2-2	0.9	59 de	100 f
Sustane 8-2-4	2.7	52 ef	450 c
Sustane 4-2-2	2.7	51 ef	250 d
Sustane 8-2-4	1.8	47 f	270 d

Nitrogen release (Tables 1,2):
- Percent nitrogen release differed among treatments (Table 1).
- 0.3 g Sustane 4-2-2, 1.8 g Phytaboost, and 0.3 g Sustane 8-2-4 had the greatest % of nitrogen released from grit applied (Table 2).
- 1.8 g Sustane 8-2-4, 2.7 g Sustane 8-2-4 and Sustane 4-2-2 released the least % Nitrogen with only 47, 51 and 51%.
- Total N release was greates from Phytaboost at the 2.7 and 1.8 g application amount.

Nitrogen release equations (Table 3, Figures 3,4,5,6):
- Slopes and intercepts among treatments differed depending on how much grit was applied.
- Because the data were fit to a log transformed equation , it implies that the rate of release was greater during the first 30 days with release slowing after that
- 3 applications of 0.9 g of Phytaboost and Sustane 8-2-4 had the highest intercepts, 932.47 µg N and 927.04 µg N.
- 0.3 ug grit/g soil release of Phytaboost and Sustane 8-2-4 were similar but Sustane 4-2-2 had slower nitrogen release (Figure 3).
- Sustane 8-2-4 and Phytaboost had similar slopes at the different application timings for 0.9 g of grit.

Table 3. Natural log Nitrogen release equations with transformed intercepts for how much Nitrogen is added into soil.

| Grit	Amount (g/250 g soil)	Equation	Intercept (µg N)	Standard Error (Intercept)	Standard Error (X-Variable)	R-Square	Significance F
Phytaboost	0.3	y = 5.03 - 0.0513x	153.57	0.147	0.00728	0.91	8.80E-05
Sustane 8-2-4	0.3	y = 4.50 - 0.0512x	89.79	0.350	0.0189	0.65	0.054
Sustane 4-2-2	0.3	y = 4.99 - 0.0979x	146.94	0.410	0.0197	0.89	0.016
Phytaboost	0.9	y = 5.52 - 0.0203x	248.68	0.277	0.00798	0.56	0.052
Sustane 8-2-4	0.9	y = 5.75 - 0.0221x	315.28	0.0600	0.00196	0.96	2.88E-05
Sustane 4-2-2	0.9	y = 4.95 - 0.0206x	140.81	0.139	0.00512	0.76	0.0101
Phytaboost	1.8	y = 6.60 - 0.0332x	734.91	0.116	0.00345	0.91	4.89E-06
Sustane 8-2-4	1.8	y = 6.31 - 0.0120x	550.77	0.112	0.00362	0.61	0.0131
Sustane 4-2-2	1.8	y = 5.85 - 0.0170x	346.09	0.0403	0.00120	0.96	1.87E-07
Phytaboost	2.7	y = 6.84 -0.0224x	932.47	0.112	0.00230	0.86	3.63E-05
Sustane 8-2-4	2.7	y = 6.83 - 0.015x	927.04	0.0874	0.00222	0.85	1.00E-04
Sustane 4-2-2	2.7	y = 6.32 - 0.0165x	555.85	0.0776	0.00203	0.88	1.89E-05
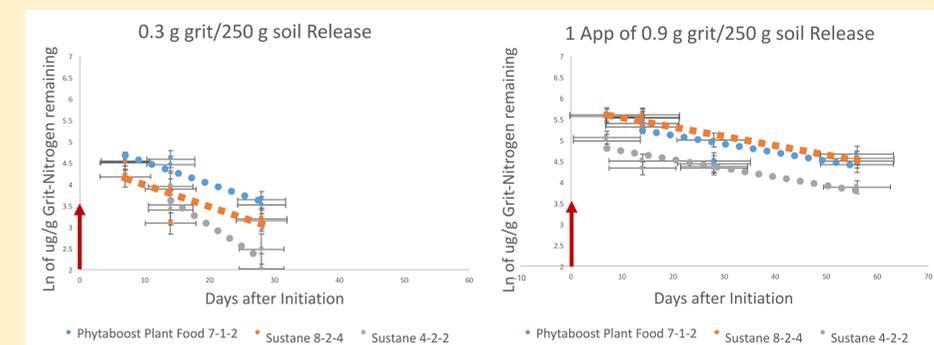
Figure 3. Natural log regression of nitrogen release from 0.3 g treatment. Arrow depicts when grit was applied.

Figure 4. Natural log regression nitrogen release in the 0.9 g application treatment applied as a single application. Arrow depicts when grit was applied.
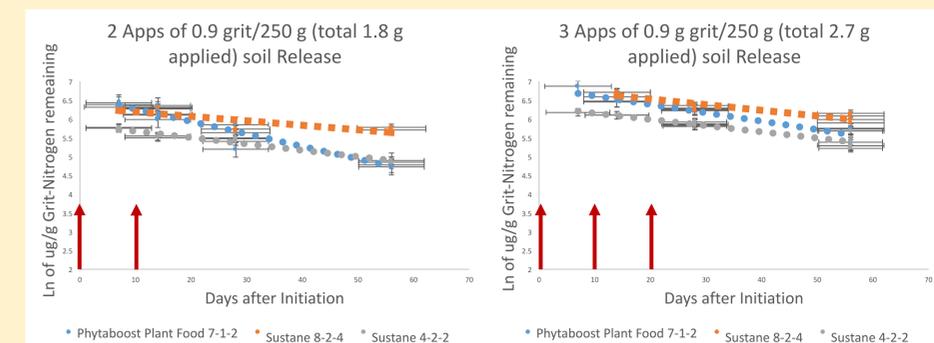

Figure 5. Natural log regression of nitrogen release if the grit was applied twice as in-season treatments. Arrows depict when grit was applied.

Figure 6. Natural log regression of nitrogen when 0.9 g was applied over a 20 d period, simulating 3 in-field grit applications. Arrows depict when grit was applied.

References

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Acknowledgements

Conclusions & Future Work

- Phytaboost released more nitrogen over 56 d than Sustane 8-2-4 and Sustane 4-2-2 at 0.9, 1.8, 2.7 g applied.
- Sustane 8-2-4 and 4-2-2 had similar rates of nitrogen release over 56 d but differed on percent N released from the grit depending on amount added to soil.
- Phytaboost had fastest nitrogen release when applied as a single treatment of 0.9 g, but multiple applications slowed nitrogen release.

Future Work:
- A greenhouse experiment will be initiated to determine if nitrogen released from the grit can influence plant growth.